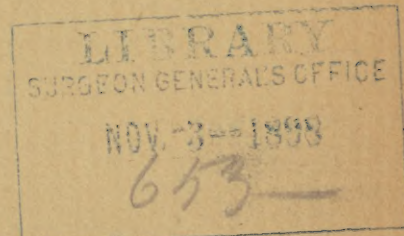


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# STUDY OF THE NORMAL TIBIA

*presented*  
BY  
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REPRINTED FROM THE AMERICAN ANTHROPOLOGIST, OCTOBER, 1898

WASHINGTON, D. C.  
JUDD & DETWEILER, PRINTERS  
1898





## STUDY OF THE NORMAL TIBIA<sup>1</sup>

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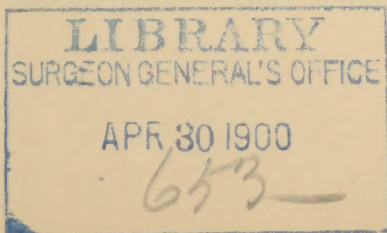
The study of the tibia is one of a series of investigations undertaken by the writer on the large collection of normal bones in the New York College of Physicians and Surgeons. The opportunity for the study he owes to the professor of anatomy of the college, Dr E. Huntington.

The records represent an analysis of data derived from the examination of about 2,000 normal adult bones of persons of various nations and both sexes, and they show the variations in the shape and in the size of the tibia which occur in the white people. Additional studies were made on tibiae of negroes and of American Indians.

The most striking peculiarity of the normal tibia is its variability in shape. The bone is hardly ever exactly alike in any two skeletons, and it will occasionally differ markedly in the same body.

The differences in the extremities of the bone are relatively less. They will be referred to later. The variations in the shape of the shaft are very numerous; they can best be appreciated when we study the shaft in transverse sections, and especially when these are made at the measured middle of the bone. The lower part of the tibia is, as a rule, less well defined than its middle, and the upper part of the bone is in very many cases

<sup>1</sup> Preliminary report; read before the American Association for the Advancement of Science, August 25, 1898.



disturbed in its shape by a greater or lesser overgrowth of the oblique ridge to which is attached the soleus.

Although variations in the shape of the sections of the shaft of the tibia are almost endless, yet many are only of a secondary character, and the shapes may be reduced to six principal groups or types. (Illustration of these types was given by plaster sections at the middle, by specimens and by drawings.)

The shape of the shaft most frequent in both the white male and the female is that of a *prism*. About three-fifths of all tibiæ are of this variety, but the prism shows two very pronounced forms. In a certain number of cases the outline of the prism will approach more or less that of a *right triangle*. The posterior surface of the bone in these cases faces directly backward, or nearly so. In the second class of prisms the posterior surface of the tibia faces more or less outward, and the base of the triangle formed by a section of the shaft is constituted by the internal instead of by the posterior surface of the tibia; we have here a distinct *lateral prism or triangle*.

Numerous cases present a transition between these two types.

The next modification of the shaft is characterized by a *pronounced concavity involving the upper two-thirds of the external surface of the tibia*. Very pronounced concavity is met with more frequently in the male than in the female. It almost always affects both the tibiæ in the same subject, and it reaches the highest degree in bones that show external curvature. This character is very frequent in the tibiæ of the American Indians.

The fourth variety is a *more or less quadrilateral shaft*. The posterior surface of the bone in these cases is divided by a vertical ridge, descending from the oblique ridge to below the middle of the bone and dividing the posterior surface of the tibia into two distinct lateral surfaces. This type is seldom seen in the female.

The fifth type of shaft is that in which *the interior border is indistinct and the posterior surface and sometimes the whole posterior half of the bone is convex or oval*. This variety of tibia is almost entirely restricted to the female sex.

The last variety of the shaft includes those cases in which *the whole shaft is irregularly oval*. In these cases there is a marked convexity of the external and the posterior (always postero-lateral in these instances) surfaces. The internal surface may



be flat. These sections, but not so much the whole bones, approach very closely the sections obtained on the tibiae of the gorilla. Among whites this variety is rare; it is frequent among negroes; I have not met with it among the tibiae of Indians.

The *size* of the tibia shows also many variations.

All measurements very frequently differ, not only in different subjects, but also on the two sides of the same body. The left tibia is in both sexes slightly longer on the average, but to this there are many individual exceptions. The average male tibia is distinctly longer than that of the female. The average length of the male tibia on the right was 36.45 cm.; on the left, 36.48 cm. In females the right tibia measured on an average 34.5 cm.; the left, 34.6 cm.

The scale of length in the male varies from 31.0 to 45.5 cm., and in the female from 28.0 to 39.0 cm.

In the male the right tibia was found longer in 42.8 per cent of the cases; the left longer in 25 per cent; equal length in 28.6 per cent of the cases.

In the female the right bone was the longer in 31.8 per cent; the left in 54.5 per cent; the bones were equal in 13.6 of the cases.

There are some racial variations in the length of the tibia.

Diametrical measurements of the bone were taken both at the middle and at the height of the nutritive foramen. The displacement of the bone was also noted.

The writer advises that preference be always given to measurements at the measured middle of the tibia, as they were found to be by far the more stable. Measurements at the nutritive foramen are in almost 60 per cent of cases influenced by the oblique ridge of the soleus.

Another objection is that the nutritive foramen lies at a variable distance from the upper articular surface of the tibia. This distance differs both in different subjects and in the tibiae of the same skeleton. In about 1 per cent of cases the foramen will be double.

The measurements taken at the middle of the tibia show the following proportions:

The average antero-posterior diameter at this height is in male, on the right, 3.13 cm.; on the left, 3.14 cm. In the female

the antero-posterior diameter is on an average, on the right, 2.72 cm.; on the left, 2.57 cm.

The variations in the male are from 2.6 to 3.7 cm.; in the female from 2.0 to 3.3 cm.

The lateral diameter of the tibia at middle averages in the male, on right, 2.24 cm.; on left, 2.20 cm.; in female, on right, 2.05 cm.; on left, 1.86 cm. The variation of this measurement is from 1.7 to 2.95 cm. in the male, and from 1.8 to 2.2 cm. in the female. Equality in diametrical measurements of the bone on both sides in the same subject was observed, with the height, in 14.7 per cent of the male and 52.4 per cent of the female; with the lateral diameter, in 15.4 per cent in male and 38.1 per cent of the female.

The measurements at the nutritive foramen—those which are unaffected by the oblique ridge—are always greater than those of the corresponding measurements at the middle. The average difference in the height is in the male about 5 mm., in the female about 2 mm.; while the average excess of width amounts in the male to a little over 3 mm. and in the female to a little less than 2 mm.

At the nutritive foramen the tibia is, on the average, relatively somewhat higher and narrower than it is at the middle.

The width-height index at the middle in the male averages 71.1, while at the nutritive foramen it averages but 70 per cent. The same indexes in the female are, respectively, 71.9 and 69.6.

Thus it may be said that the tibia, while in both sexes it is of about the same proportionate thickness, is about 2 or 3 per cent more platycnemic at the nutritive foramen than at the middle.

Pronounced flatness of the tibia, so common in all American native races, is very rare in both whites and negroes.

The *weight* of the tibia was found to differ very considerably in its relation to the size of the bone at different ages. The weight can be properly compared only with the displacement or volume of the whole bone. This volume can be secured in three different ways: (1) approximately and unsatisfactorily, by calculation from the different measurements; (2) very satisfactorily and accurately, but in a very laborious way, by shot or seeds; (3) in a not absolutely accurate, but fully efficient way for the comparisons desired, by immersing the bone in a graduated jar in some heavy liquid. The author used glycerine.



The proportions of weight to volume thus obtained were secured by dividing the displacement in cc. by the number of milligrams of weight. The results were, in general, as follows:

The tibia is heaviest in proportion to its volume between 20 and 40 years of age. Above forty, the proportion of weight to volume diminishes. This diminution, which means a rarefaction of the bone, is not equal in every subject nor even in the two bones of the same subject in some cases. The indexes obtained varied from 8 in young adults to over 30 in some of the aged, showing that bones in old subjects may diminish to one-third or even one-fourth of their original weight. The diminution is more marked in females. Pathological causes may influence this process.

The *head* of the tibia was generally found to be larger in the male than in the female in proportion to the length of the bone. The width as well as the depth of the upper articular surfaces is greater in the male.

In about one-half per cent of the specimens examined the head, and with it the articular surfaces, of the tibia was found to present a very pronounced inclination backward; this is not uncommon in some Mexican Indians.

*The Spine.*—Average length—on right, 5.1 mm.; on left, 5.0 mm.; extremes—on right, 2 to 9 mm.; on left, 3 to 8 mm.

The length of the spine is not dependent on the length of the bone; may differ on the two sides of the same body, but the differences are less frequent than are those of the length of the whole tibia. The male spine is, on the average, slightly longer.

As to the signification of the above studies the author states the following:

*The variations of tibia are much more numerous in individuals of the white races than they are in any other races* in which he had an opportunity to examine the tibia. In both the pure negro and in the American Indian its shape is less variable.

The male tibia is, on the average, better differentiated than that of the female. This is apparently due in part to the greater muscular activity of the male, and partly to a persistence in the female tibia of more or less of the infantile character of the bone.

The source of the numerous variations of the shape of the tibia cannot be definitely and satisfactorily traced.

The considerable want of regularity in the length and strength of the tibia on the two sides of the body leads the writer to believe that such differences are in many instances due not to innate conditions, but probably to acquired habits and also to the occupation of the individual.

The author will endeavor to follow this with a detailed report as soon as possible.











